

Bond Assembly FOD Zones – A Procedure for Assuring Acceptable Adhesion

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Rocket Motor Perspective on Adhesion



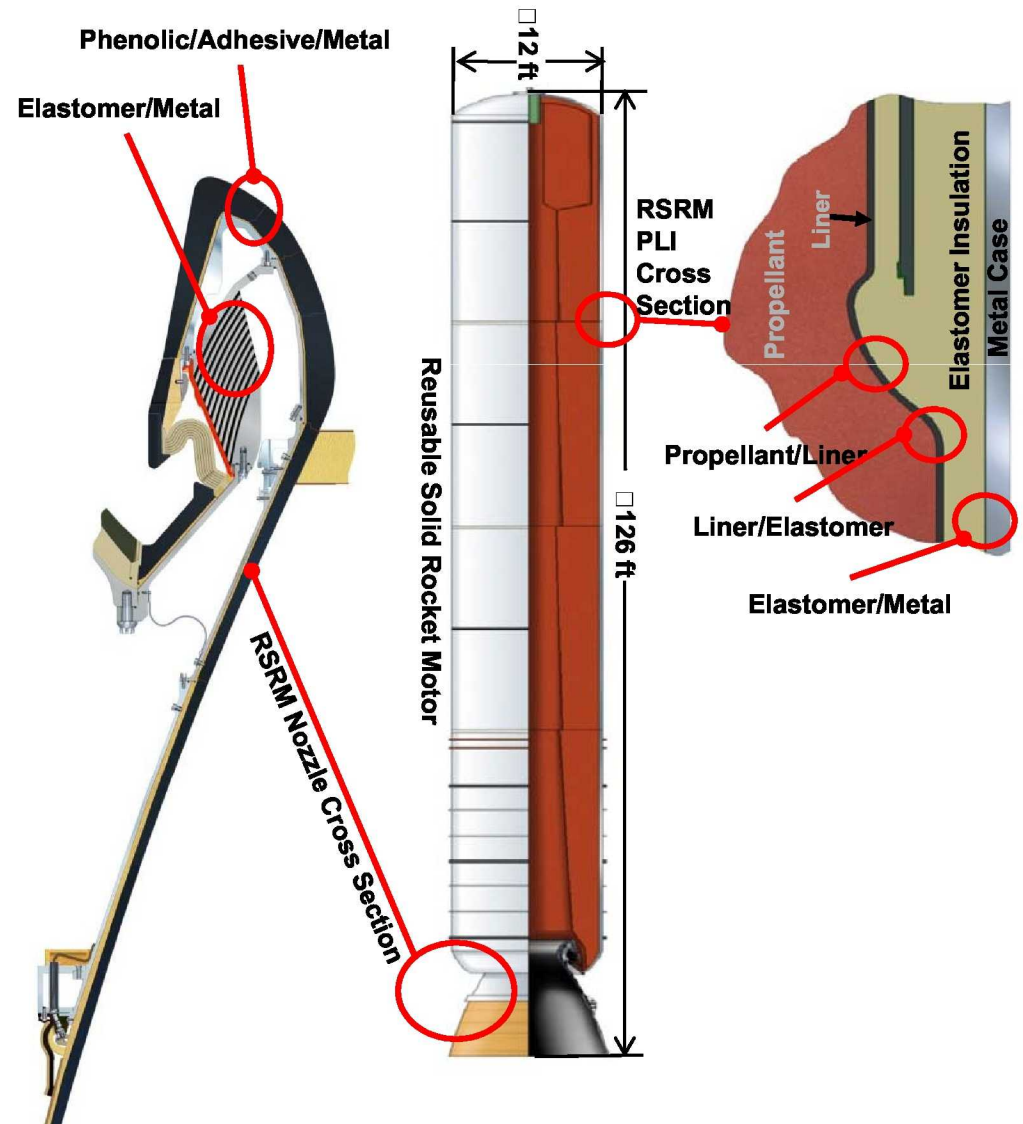
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Rocket motor components are primarily assembled by adhesion.

- For example, the RSRM (Reusable Solid Rocket Motor - part of the Space Shuttle Boosters) system contains $\approx 10,000 \text{ ft}^2$ of bondline area.
- Rocket motors contain a variety of adhesive/substrate bond systems
- Bond system performance requirements also vary.

To assemble reliable components, ATK Space Systems and customers invest substantial resources to the study of bond assembly processes.

- Surface and adhesion science
- Adhesive chemistry
- Process parameters
- Contamination effects



Rocket Motor Perspective on Adhesion and Contamination



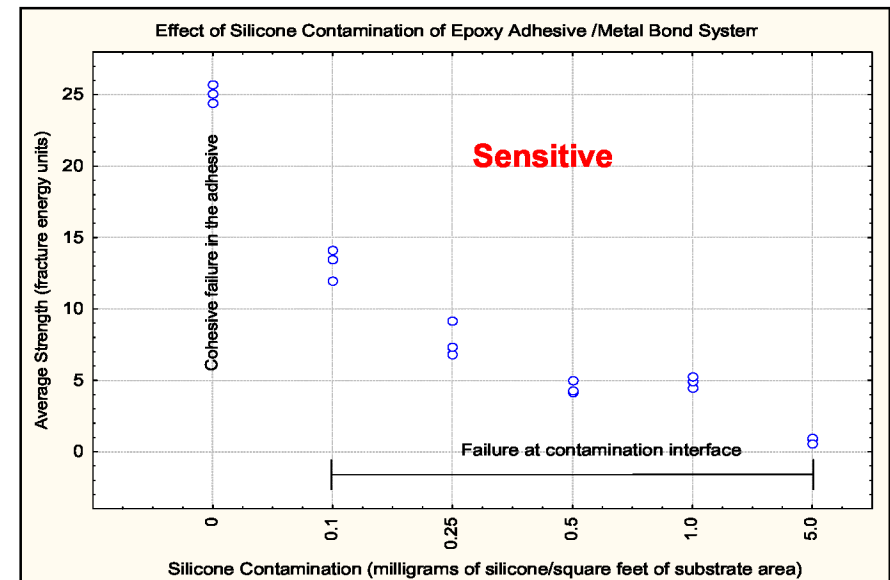
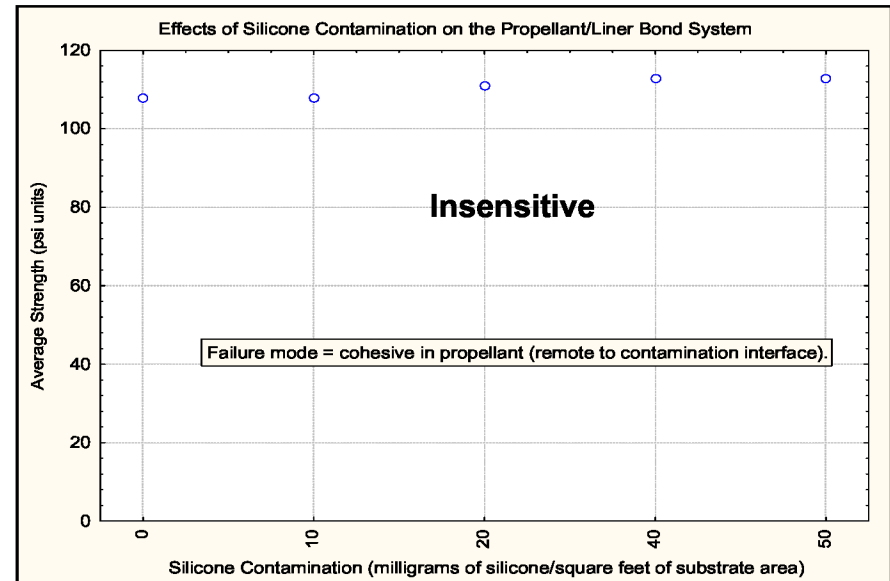
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Contamination sensitivity of rocket motor bond systems varies.

- Insensitive = no strength reduction and usually failure remote to the contamination interface.
- **Sensitive = strength reduction and failure at the contaminated interface.**

To prevent bond system failure, operations is vigilant about contamination control.

- Tight control is exerted on a wide range of process contaminants; e.g., greases, oils, tape residues, particulates, release agents, etc.



The Consequences of Extreme Contamination Control Requirements



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The effect of incongruous forces:

- ATK adopted a zero-tolerance contamination requirement.
- ATK developed greater fidelity in contamination detection.

Extreme Requirements + Better Detection = Production Paralysis

Over zealous contamination control negatively affected production **sensibility, efficiency, and ergonomics.**

Sensibility

- Tight control - indiscriminately applied to all manufacturing areas regardless of bond system.
- “Silicone-centric” - inordinate amount of focus on silicone contamination diverted attention away from other release agents such as dioctyl phthalate (DOP) or fluorocarbons.
- Upper management mandated a silicone-free plant regardless of its ubiquity.
- “No silicone allowed” requirement applied to all process support materials (PSM) regardless of proximity to bond assembly processes.
- Unusual requests to test PSM for silicone content.

Silicone content testing atrocities

- Grease
- 3-in-1 oil
- Shoelaces
- Toothbrushes
- Ratchet tie-down
- Magnetic signs
- Cut back tool
- Bug sprayers
- Mold release
- Mouse pads
- Rubber mallets

The Consequences of Extreme Contamination Control Requirements (Continued)



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Efficiency

- There was a higher rate of production discrepancy reports.
- Many plant-wide shut-downs occurred because of detection of infinitesimal silicone amounts in PSM.
- Quality Assurance Lab was inundated with requests to test materials for silicone content.

Ergonomics

- Effective use of functional PSM was limited or even prohibited because of negligible silicone content.
- In some cases, opportunities for safety improvement were missed.



A Smarter Approach to Contamination Control



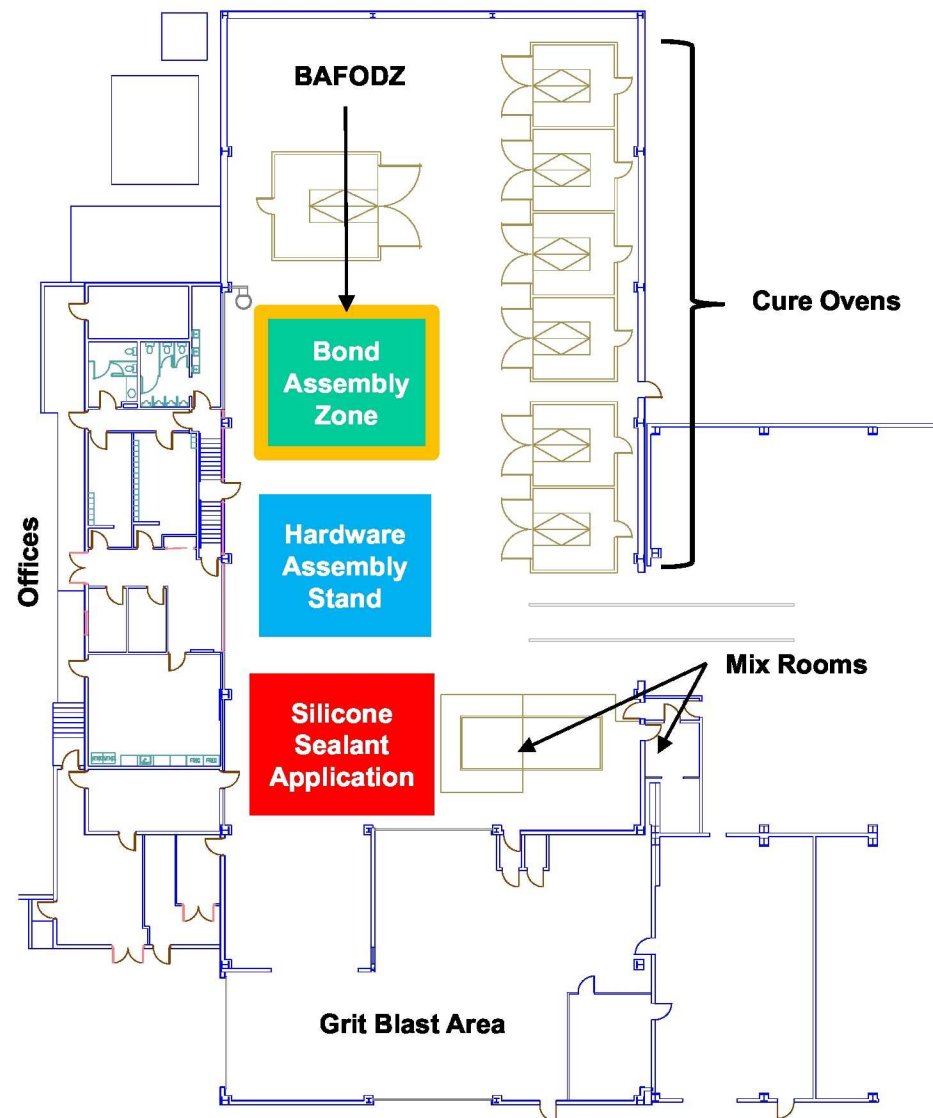
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ATK Operations recognized the inefficiency of its contamination control approach and made a prudent change.

The Bond Assembly FOD Zone (BAFODZ) Concept

- Essentially, a BAFODZ is a more tightly controlled area within a standard FOD zone.
- Geographically-based zone – area within the manufacturing center
- Chronologically-bounded – delta time between substrate surface preparation and adhesive application
- Controls the flow of contaminants into the bond assembly area.
 - Control is exercised according to bond system sensitivity.
 - Control is applied during critical bond assembly steps.
- Allows for more flexible use of PSM in other areas of the manufacturing centers.

Floor Plan of a Manufacturing Area



Bond Assembly FOD Zone - Method of Execution



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BAFODZ Implementation Protocol

Manufacturing Centers

- Continue with standard FOD mitigation practices.
- List allowable BAFODZ PSM in the manufacturing planning.
- Consistently educate operators on contamination control practices.
- Control PSM changes through quality and engineering review boards.

Quality Assurance

- Watchfully assess release agent levels in incoming PSM.
 - Outside the BAFODZ - allow for reasonable release agent content in PSM that provide an ergonomic advantage to manufacturing.
 - Inside the BAFODZ – exercise tight control of release agent content in PSM.
- Work with vendors to procure release-agent-free PSM whenever practical.

Engineering and Materials & Processes (M&P)

- Reassert confidence in the contamination cleaning effectiveness of production surface preparation processes.



Bond Assembly FOD Zone – Manufacturing Centers

Method of Execution



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Continue with standard FOD mitigation practices.

- FOD sweeps
- Contamination control area plan
- Bonding area readiness check list

List allowable BAFODZ PSM in the manufacturing planning.

Consistently educate operators on contamination control practices.

Control PSM changes through quality and engineering review boards.

0-01(902) 15 OCM = 02N0000003966]

Operation 0260 | Tools | Materials | Facilities | Procedures | Engineering | Instruction

0075

FOD sweep of the FO process control zone:

Start Include - Context: 7 DocName: FOD_NOZZLE_BOND_ASSY File: FOD_NOZZLE_BOND_ASSY.xml Rev: 1

Verify that a FOD sweep of the FO process control zone has been performed prior to the start of the process. Any object, substance, or material that is alien to the hardware, process, product, or material must be removed and a visually clean level of cleanliness exists before any work begins IAW FOP-0416.

MFG

End Include - Context: 7 DocName: FOD_NOZZLE_BOND_ASSY File: FOD_NOZZLE_BOND_ASSY.xml Rev: 1

0080

Add similar Bonding FO Zone start designations.

Insert Material

Material Nbr 01-172033-001

Description GLOVE, NITRILE SMALL

Issue Unit Cd BG Use Type Cd Process

Mfg Qty ASREQ ADCAR Cd NONE

Inspect Cd Q Buyoff Cd NONE

Srl Lot Cnt 0

☐ Optional Flag

☐ CCSN Flag

☐ Critical Flag

Comment BONDING FO ZONE APPROVED

Designate if material is FO Zone or Bonding FO Zone approved.

OK Cancel

Bond Assembly FOD Zone – Quality Assurance Method of Execution



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Watchfully assess release agent levels in incoming PSM through acceptance testing and vendor certification.

- Outside the BAFODZ - allow for reasonable release agent content in PSM that provide an ergonomic advantage to manufacturing.
 - Note that the allowables were determined from contamination sensitivity testing.
- Inside the BAFODZ – exercise tight control of release agent content in PSM.

Work with vendors to procure release-agent-free PSM whenever practical.

Success stories:

- ATK successfully negotiated a contract with 3M to provide silicone free Scotch Brite abrasion pads.
- ATK successfully worked with Ansell to develop low silicone cut—resistant gloves.
- ATK successfully worked with Westex Inc and American Safety Clothing to eliminate the use of silicone in the production of protective garments.
- ATK works with Elder & Jenks to manufacture paint brushes without brads, nails and silicone



Cut Resistant Gloves



Brushes

Bond Assembly FOD Zone – Engineering and M&P Method of Execution



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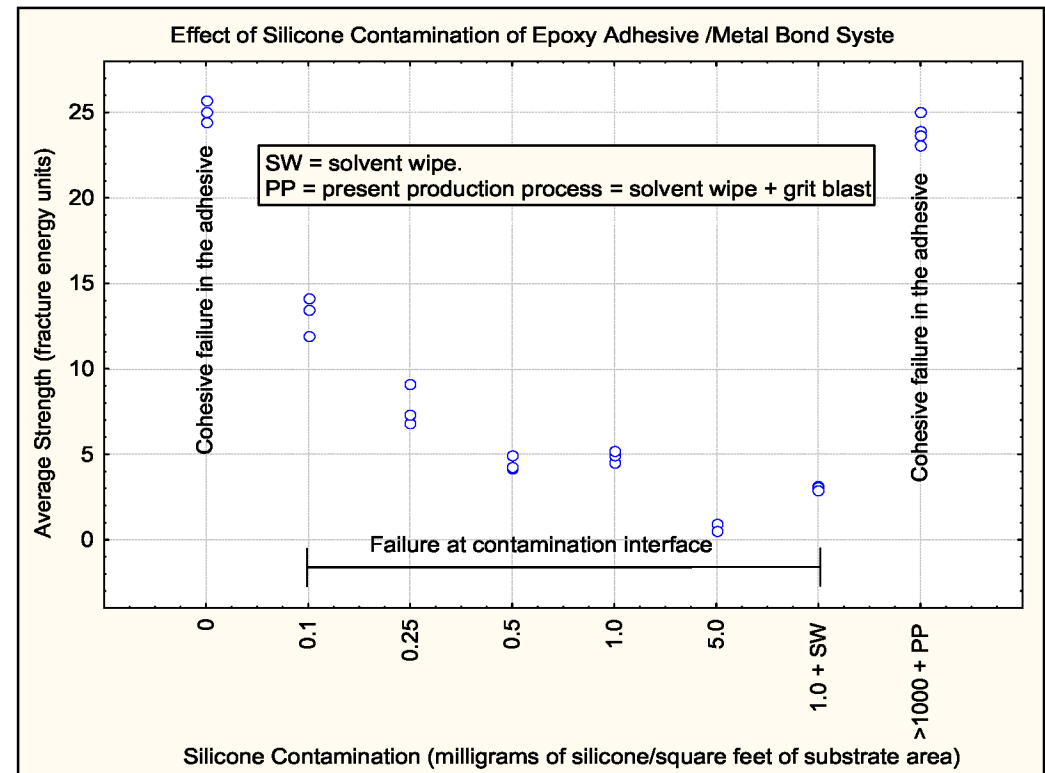
Reassert confidence in the contamination cleaning effectiveness of production surface preparation processes.

Chronologically defines the beginning of the BAFODZ.

- Manufacturing applies a “no touch” practice after surface preparation.

Impressive ATK database shows that surface preparation processes are generally effective contamination removal methods.

- Confirms that production surface preparation processes remove contamination accumulation from upstream processing.
- If the surface preparation process is insufficient then Engineering and M&P must develop more effective method.



Conclusion and Acknowledgements



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Improved approach of manufacturing to contamination is more sensible.

- Recognize the reality that release agent contamination is pervasive because of its functionality.
- Some bond systems are sensitive to many contaminants and the substrates must be protected accordingly.
- Other bond systems are insensitive and do not require the same degree of protection.
- The risks of contamination can be managed in a more proactive manner.
 - Trust the surface preparation process.
 - Do not contact the hardware after surface preparation.
 - Do not apply tight contamination content standards to PSM that are not used in a critical bond assembly area (BAFODZ).
 - Focus vendor attention on release-agent-free PSM for items where it is warranted by sensitivity.

Acknowledgements

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